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While on a trip west last spring I took the opportunity of visiting the remarkable formation in Arizona known as Coon Butte, also called "Meteor Crater." This formation has been made the subject of several memoirs which have appeared from time to time during a number of years past. To these papers references may be made for details of exploration and measurements. In view, however, of the marked divergences of opinion concerning origin, it seemed desirable to determine, at least to one's own satisfaction, which of the explanations was in accordance with the facts. The spot had been known for many years as the locality for numerous meteorites, unique in containing diamonds; the so-called Cañon Diablo specimens. Cañon Diablo is a few miles west of the crater.

More recently these iron masses have been found to contain notable amounts of platinum and iridium, metals which have in the past few years advanced in price at an extraordinary rate.

The careful study of the class of bodies which include meteorites can doubtless assist us materially in understanding what goes on in the universe around us. They are messengers with a story. My personal interest was aroused when I was a fortunate witness to the great meteor shower in the early morning of November 14, 1867. This shower which was recurrent in thirty-three years was found to be due to meteoric masses, the path of which was identical with the orbit of Tempels' Comet, which was undergoing disintegration. Owing to some perturbation or displacement of the orbit the visitation failed to reappear in 1900.

In reaching the Meteor Crater we ride west over the Atchison, Topeka and Santa Fe railroad enjoying the wonderful scenery of the Painted Desert, its coloring and atmosphere. We may comfortably pass the night at Winslow in northern central Arizona. Taking the train next morning toward Sunshine Station, a few miles further

west, if we are intent on noticing the peculiarities of the land around us we will soon see off to the southwest and rising out of the nearly level plain a peculiar hill or elevation; a butte with an apparently flat top and whose slopes have a grayish color distinguishing it completely from the red soil which covers this territory. Though it may be eight or ten miles away it is still a conspicuous object not from its height but from its form. It has an artificial look as if some great reservoir for water storage had been built. There is no other elevation near it. From Sunshine Station it is reached by a drive south of about six miles, over the plain sparsely covered with vegetation, and with here and there outcropping fantastic forms of red rock of a few feet in height.

As we approach Coon Butte, or Meteor Crater, the impression does not change except in the realization of the scale on which it exists. Distances are so deceptive in the clear air of the desert that it had seemed close at hand when we were still miles away. At last we reach the foot of the slope and climb it to a height of about 150 feet. We are now at the top looking down into a great bowl-shaped hole, the upcast rim of which we had seen from afar. This rim is a nearly circular ridge, very steep or even vertical on its inner part and sloping gradually to the plain on all sides. But the thing which rivets the attention is the deep cavity enclosed by this rim, comparatively flat at the bottom with surrounding talus slopes from the walls, in which walls are exposed various rock strata, broken, contorted, distorted, and uplifted. The bottom of the crater is about 570 feet below the rim, or more than 400 feet below the general level of the plain outside.

The sight is most impressive. The diameter of the opening is roughly three quarters of a mile; at the widest part a little over 4,200 feet.

The circular hill or rim of this huge hole is composed of material evidently uplifted, crushed and pulverized in part and cast out from the crater. Much of it is finely pulverized white silica from a white sandstone which underlies an upper stratum of limestone. Fragments of the limestone layer of all sizes are seen; some of them very large. The slope of the rim extends for about a quarter to half a mile but there is scattered material three miles or more away. Blocks of limestone and sandstone cap the ridge, ranging up to 30 feet in diameter, while one block 10 feet through, is half a mile distant. The most significant constituent of the upcast ridge, is, however, meteoric iron in pieces of varying size, and so-called shale ball iron or oxidized meteoric iron; — oxidized because in its composition there was chlorine

enough to cause rapid rusting after it entered the earth's atmosphere and became subject to moisture.

The plain around the crater has yielded numerous masses of the iron, some of them several hundred pounds in weight, and one discovered during the past summer weighs about 1700 pounds.

The amount of rock blown out of the crater cavity could not have been less than two or three hundred millions of tons, not considering the large amount which fell back and which now lies at the bottom of the bowl-shaped hollow of the crater. Nowhere else on the earth's surface has meteoric iron been found so spread about.

Yet there remains an unsolved problem. What became of the enormous meteoric mass, or the cluster of them which was capable by its impact of displacing so large an amount of rock? Allowing only one ton to every 20 or 30 tons of ejected material, we still have about 10 millions of tons of meteoric iron to account for. This would constitute a solid mass of between 400 and 500 feet in diameter.

The attempts to explain this crater as the result of volcanic action, or as produced by a steam explosion from below, are certainly to be regarded as rather far fetched in view of the presence and mode of occurrence of the meteoric irons, and the many evidences presented which seem to me to lead inevitably to the conclusion that here indeed we have a huge impact crater and that only. The floor of the crater is overlain with sedimentary deposits of an aquatic nature, the washing of the walls and talus indicating the existence at some time of a small lake or pond. Below this is a vast bed of mingled materials, mostly, however, the pulverized white sandstone or "rock flour," the result of crushing of the rock layers such as now surround it.

For exploration a shaft has been sunk into this bed of a nearly pure silica, but contrary to expectations it had to be discontinued. Water was reached at about 200 feet below the crater floor and the extremely fine silica rock flour thus became a most typical and troublesome quicksand and limited the depth of the shaft. Recourse was had to drill holes, about 28 of which have been sunk to various depths not far from the central area, and some of these have reached the underlying and undisturbed red sandstone layer at about 850 feet below the crater bottom.

The material brought up has shown evidence of disseminated meteoric iron and nickel, but no large masses were found. Specimens of the silica metamorphosed by heat and steam under pressure, causing a partial aqueous fusion, have been secured.

Careful magnetic tests conducted by Prof. W. F. Magie, head of the Physics Department at Princeton, have failed of result, probably because

these iron masses have too low a magnetic susceptibility under the very small values of magnetic force such as exist at low latitudes; particularly as the vertical component can alone be expected to yield indications of the presence of buried masses of iron.

If further exploration is carried on it is possible that a system of induction balance testing as proposed by me would be more fruitful, though experiment alone could determine that fact.

From many considerations which it would take too long to enumerate it seems probable that if a large mass or cluster has buried itself at this spot, it now exists under the southern and southwestern wall of the crater and not near the center. It is a significant fact that the rock layers exposed under the rim at the south show evidences of an uplift of about 100 feet while still retaining their approximately horizontal position. The depth of penetration is probably not more than 1200 feet, in which case the buried masses would lie upon or be slightly embedded in the upper part of the underlying red sandstone layer, which the bore holes put down near the center of the crater have shown to be undisturbed there.

In a recent report referring to Coon Butte, Bulletin 435 of 1910 of the United States Geological Survey, Mr. N. H. Darton says: "After an examination of the crater and consideration of all that has been written, I believe we have no evidence adequate to explain its origin. The hypothesis that it was caused by the impact of a meteor as urged by Tilghman, Barringer, Fairchild, and Merrill is in accordance with some of the features but does not accord with the all-important fact that no meteor is present, as has been demonstrated by many borings." He forgets that only 28 test holes were put down and all near the center of the crater and that such bodies rarely if ever fall vertically. If a single large mass of 500 feet in diameter fell, to be sure of finding it would demand the sinking of not less than 500 to 600 holes if the whole crater is to be explored. He says further: "It is agreed that if there was a meteor it must have been at least 500 feet in diameter. The occurrence of a few tons of meteoric iron in the vicinity and mingled with some of the debris on the rim and in the crater is an enigma." He goes on to favor a suggestion by Gilbert that it was a volcanic steam explosion that produced this crater, forgetting again that the real key to the situation is the presence of the meteoric iron in the way it is found to exist.

A considerable expenditure of time and money has been made in exploring this unique crater. This has been carried on largely by Mr. D. M. Barringer, to whom belongs the credit of pointing out the meteoric origin of the crater and collecting the proofs thereof. To him

I am indebted for the opportunity of conveniently visiting and examining the formation, and also for publications, charts, slides, and other material.[1]

The uncovering of a mass of millions of tons of iron containing about 8 per cent nickel would have great commercial value. Add to this the fact that analyses show the iron to contain an average of about 6/10 ounce of platino-iridium to the ton and the value is much enhanced. Besides, there is an undetermined amount of diamond present.

All of the iron examined and even the oxidized shale ball iron shows the characteristic Wiedmanstatten figures regarded as proof of meteoric origin. Such a structure, it may be remarked, is probably the result of slow cooling in the interior of a large body and under compression. This structure is stated to disappear when the iron is heated to about 900° C.

What happened at the Meteor Crater may be briefly outlined as follows: A large mass, or more probably a cluster resembling a small comet, passed so near to the earth as to be deflected sufficiently to cause it to strike. Its velocity, reduced by retardation in the air, may have been not more than two or three miles per second when it struck earth. As it penetrated the dry plain some of the smaller and still more retarded and slower moving pieces following in the rear of the main cluster were diverged therefrom and so fell at various distances around the crater. As soon as the main body reached the wet rock layers superheated steam was generated at high pressure, pulverizing and metamorphosing the silicious rock, and producing an enormous lateral pressure which the disturbed and uplifted strata together with the horizontal compression as shown in the structure of adjacent rock masses clearly indicate. As the mass advanced the pulverized material in its path and around it would be swept backward almost as a fluid and would expand outwardly at the same time, fracturing the adjacent rock layers, up-casting and folding back the strata, and discharging the enormous mass of pulverized and mixed rock material which now forms the circular rim. This blast would entangle the

[1] Mr. D. M. Barringer, conceiving the impact theory to be the correct one, collected largely at his own expense, and through a period of years, the evidences thereof and has published his results in the following papers, to wit, "Coon Mountain and Its Crater," Proceedings of the Academy of Natural Sciences of Philadelphia, December, 1905; "Meteor Crater in Northern Central Arizona," read before the National Academy of Sciences at its meeting at Princeton, November 16, 1909. To these papers of Mr. Barringer reference may be made for an abundance of interesting detail with illustrations and maps.

smaller fragments of meteoric iron now found in the rim. Finally, as the masses of material came to rest there would settle back into the excavation a large part of the pulverized material leaving the sheer rock walls as they now are, upturned at various angles even to almost complete inversion in some places. The material which did not fall back to the crater would rest on the upcast walls and slope away upon the surface of the plain in a fairly symmetrical manner. In their flight through the air the iron was burning into oxide; the heat and debris were left behind in the wake or trail. What reached the earth was comparatively if not actually very cold, retaining in its interior, as it were, something of the cold of space.

It may be of interest here to present if possible a brief statement of what must happen during the flight of a meteoric mass through our air. In general, the earth's atmosphere acts so effectually as a protective sheath that only a few of the very numerous bodies variously known as shooting stars, aerolites, and meteors ever reach the earth's surface. If the velocity of a body entering from the outside is very high relatively to the earth, thirty or forty miles per second, for example, the crushing strains brought upon it by the air resistance in its path may be great enough to break it into fragments, while the high temperature of the compressed air opposing its movement melts or vaporizes the material composing it. Stony masses, like pieces of rock, would yield to fracture and dissemination more readily than masses of solid iron. This fact may itself account for so large a proportion of the bodies which reach the ground being composed of iron. Rock masses are occasionally found, surviving, perhaps, because of low entering velocity. The iron meteors are so strong as to resist enormous crushing strains. The metal iron is, however, so freely combustible that when exposed to a blast of hot, compressed oxygen it is burned into fused oxide very rapidly. So with the iron meteors in their flight. They are virtually blown upon by a highly heated blast of compressed air containing so much oxygen as to cause them to burn like tinder. The survival of a stony meteor, or aerolite, until it reaches the ground must therefore depend upon its entering the air at comparatively low velocities, or upon its being retarded in a long flight through the very thin higher air whereby it loses much of its initial speed before entering the denser air below, while the survival of an iron meteorite depends on its velocity being insufficient to develop crushing strains great enough to fracture it into small masses, and upon the size of the meteor itself, or of its fragments, if fractured. A small iron mass at high velocity will burn away so rapidly in the dense oxygen in front of it that the whole mass will be consumed and dissipated before any

of it reaches ground. The whole energy of the flight will go into the trail or train. The fused iron oxide as soon as formed on its surface is blown off and left behind in the trail which marks the course of the body in the air. If, however, the iron mass or fragment is large, and its velocity insufficient for crushing or further breaking, it may not be entirely burned during its flight and some of it may reach the ground or the sea while still retaining a considerable velocity. It may bury itself in the earth to a depth more or less great. In the case of an iron meteorite there are two sources of heat energy and attendant luminosity, the high compression of the air in front of it and the wastage by combustion of iron in the hot compressed oxygen. The mass is in fact virtually blown upon by a blast of oxygen in a high state of compression. As evidence of the rapidity and effectiveness of such combustion reference may be made to the work of the acetylene oxygen blowpipe now used to cut through masses of iron, as in clearing wrecks and the like. The product of the combustion in these cases is magnetic or black oxide of iron in a fused and perhaps partly vaporous state, and this is removed or blown off the surface of the iron mass as fast as it is formed. Melted pear-shaped drops have indeed been observed as falling out of the track or train left by a meteor in its course through the air. They are probably iron cinder or fused magnetic oxide. It will be understood from this that the energy given out as heat is not delivered to the body of the meteor as such, but is carried off in the air and oxide layer ripped off and left behind in the train. It has not been unusual to dig up a meteor seen to fall, and find it stone cold or only slightly warmed. Entering the air from space its temperature will naturally be very low, not much above absolute zero. Its flight in the air lasts so short a time that its conductivity for heat, even when it is of solid metal, is not adequate for the instant passage of heat to its interior. It can possess only a thin skin of hot material, a mere film in which the temperature gradient is very steep or abrupt, and this film is constantly blown off or removed as soon as its temperature of fusion is reached. This temperature is about 1500° C. The case may be illustrated by turning a vigorous blast of heated air upon a piece of ice supported in any way. The ice melts rapidly and the water formed is blown off as fast as it appears, while what remains is none the less ice to the end of the process. It is even possible that the blast be highly heated so as to boil the water formed without essentially changing the result of causing the ice to melt away rapidly but remain while so diminishing a piece of ice to the last. But the ice is not combustible. Let us therefore substitute for it a ball of wood or a mass of combustible and turn thereon a blast of hot oxygen or air. The

combustible will burn on the outside and the heat be carried off in the products of combustion blown from it; while if we stop the experiment at any time we will find the interior of the mass remaining still solid and cold.

Hence in the case of a large iron meteor there is no such thing possible as an instantaneous vaporization of the whole mass. On entering the thin upper air it will condense the air immediately in front of it, increasing its temperature and raising the density of the oxygen to a point to begin the combustion of the outer layers of the moving mass. If the velocity be extremely high, the opposing pressure in front as it passes into lower air may be sufficient to crush the mass into fragments. The smaller pieces formed will now burn and the rate of waste by combustion be greatly increased. This process may go on until the whole is consumed and dissipated in the train. But if the velocity is not high enough for this, the mass either does not fracture or the breaking soon ceases and the remaining flight is marked by combustion or fusion and the continual cleansing of the surface of its fused products, as outlined above. If any of the mass has size enough to endure the rapid waste by oxidation, there may at the last remain a greater or less fraction of the original mass, which reaches the earth's surface in the solid and relatively cold condition, embedding itself in the earth or in the sea. The indications then are that a body which has so survived will neither be moving at an excessive velocity as compared with that of a projectile from a high-powered gun, nor be a hot body on striking, except as to a mere film of its outer surface. As such bodies rarely descend vertically they must pass through many miles of comparatively dense air when their course is more or less horizontal or inclined to the vertical. This and their irregular form renders possible a very great retardation; far exceeding in proportion that experienced by a well proportioned cannon shot in its flight. If crushing or fracturing took place, angular fragments would be split off, very irregular in form, making very poor projectiles, retarded rapidly. The crushing of the mass by opposing air pressure can be compared to the result of the explosion of a charge of nitroglycerine upon a mass of iron, the effect produced being that due to a high gas pressure suddenly formed. But the pressure which would be needed to fracture an approximately round and solid mass of cold nickel iron is very great, so great in fact that it is probable that only those meteors moving relatively to the earth at the very highest velocities would experience it. In fact it may be doubted that such fracturing often occurs with a solid iron meteorite of round form, on account of the somewhat gradual retardation, smaller in the upper air and increasing as the body reaches denser air, thus gradually robbing the body of

its velocity. A large iron meteorite or a cluster of them has therefore a considerable chance of survival in spite of the rapid waste by burning, while the smaller ones may disappear by combustion while still in the air, especially if the initial velocity be high. But, entering air at a comparatively low velocity such as five to ten miles per second, an iron meteor of more than a few ounces in weight will probably survive in part. I have been particular to lay stress on these actions, as they entirely negative an idea which has been advanced to account for the failure to find large masses of embedded iron at the Arizona Crater. It has been claimed that the mass was vaporized on striking, a possibility which is *impossible*, as I am compelled to regard the matter.

The age of Coon Butte, the great Meteor Crater, is of course uncertain. How long a time has elapsed since the fall? In the absence of definite data for computation we can only guess. However, from the apparent absence of much erosion it must be comparatively recent. While the country is dry, it does rain at times and there are high winds. The climate may have been more moist in times past as is rendered probable by the evidences of water in the crater formerly. The age of certain cedar trees on the slope tend to place the date back perhaps of 500 to 1000 years. A mere surmise would be 2000 to 3000 years ago as the possible time of the meteoric fall.

It is stated that the Indian tribes inhabiting the region in a reservation just north of the railroad have an ancient tradition of the fall of a large body of fire from the sky which killed a number of their tribe. It is also stated that they now hold the spot in some superstitious awe from the fact that they send to the crater slopes for the white silica, which is sprinkled about during their ghost dances. I cannot, however, personally vouch for these statements without further investigation.

Such craters as this meteor crater if formed many thousands of years ago would probably be obliterated by erosive influences, and even in the desert the shifting sands would finally cover them. The water, the frost, vegetation, the atmosphere are against their indefinite preservation as features of the landscape. Let us imagine, however, a large body such as our moon, in a vacuum, with no atmosphere, no water, no winds, no frost, no vegetation, then, if any such impact took place the record must be left for all time; not quite unimpaired perhaps, for a subsequent impact may superpose its effect tending to obliteration of the first effect. Moreover, in the lapse of millions of years there may be accumulations of cosmic dust or small particles gathered up from space which will partly cloud over or cover the lower portions. But even in this case the higher ridges will remain. It is indeed no new idea that the lunar craters, instead of being the result of volcanic

actions, may be in fact impact craters. This idea was put forward by Proctor in 1873 and further enforced by Gilbert some fifteen years or more ago. If they are volcanic then the comparatively diminutive moon has been the theatre of tremendous volcanic disturbances, which without water or other gases and vapors would be unlikely according to the views of some authorities on volcanic action on the earth. If the lunar craters are not volcanic, then the scarred face of our moon is a record of terrific impacts of bodies of all sizes, probably occurring during its early history millions if not billions of years ago. The earth must also have shared in this bombardment, the traces of which are entirely obliterated. Perhaps its surface was at that time molten. There are marked differences between the now existing volcanic craters on the earth and the lunar craters. On the moon they do not exist along any lines of weakness as on the earth, and they have not built up chains of cinder cones topped by craters of restricted dimensions. They occur on the moon helter skelter, alongside of each other, anywhere, everywhere over its much scarred surface. They exhibit the greatest range of sizes or diameters from the smallest dots visible by our most powerful telescopes to the huge basins such as Clavius nearly 150 miles across. Large craters are dotted with others, smaller in size, anywhere, it may be on the floor of the crater or in its walls or their slopes. These parasitic craters appear to be absent in such craters as Tycho and Copernicus, which, however, with some others, are distinguished by extensive systems of whitish streaks running for hundreds of miles in a general direction radially over all irregularities of surface. Unlike the earth's great volcanoes, the floor of the lunar craters is in nearly all cases considerably below the general level of the surrounding surface.

The Meteor Crater in Arizona has this same characteristic and in fact if looked down upon from above would appear like a lunar crater transplanted to earth. The proportional depression of the crater floor to the height of the upcast rim is much the same. The outer slope of the rim and its relative extent are likewise very similar. The agreement is, to say the least, highly suggestive of a similarity of origin. The lunar craters do not show great rivers of lava coursing down the slopes and covering the lower levels. There is indeed a notable absence on the moon of such evidences. Those whitish streaks around Tycho and Copernicus, bear far more the appearance of an instantaneous scattering of material in a vacuum (and therefore moving outwardly in a straight course) than they do of product of a prolonged volcanic eruption which in the case of such large craters must have lasted for years. Any such surrounding deposits would have been

spread more generally and uniformly around the crater instead of in streaks. The appearances suggest a sudden splash. The central mountain or hill, so common a feature of the larger lunar craters, shows no volcanic vent. Its existence is then more compatible with the idea of a reaction, or "kick back," an inrush similar to that which occurs on dropping a stone into a pool of water, except that in the case of the lunar crater it is composed of solid fragments or more or less pulverized rock. This central hill is absent in the smaller craters, as in those comparable in size with the Arizona Crater. The most ancient craters on the moon have had time to become softened in outline and in a measure obliterated by cosmic dust. This may be the reason why so few show the system of radiating streaks so characteristic of Tycho and Copernicus. A thin lunar atmosphere, afterward lost, may have prevented their formation. The fact that the craters of Tycho and Copernicus are so clean cut, so sharply defined, so deep, free from parasitic craters or subsequent impacts, and still surrounded by the extensive, unobliterated system of streaks, would in this view, make them the result of the very latest or more recent large impacts which the moon has sustained.

The hypothesis of meteoric origin for the lunar craters has been combatted on the ground of the absence of tangential or grazing impacts. There may be some reason for this absence. If most of the effect was due to the fall of bodies moving in a general path similar to that of the moon, we could understand the case as one in which the gravitation of the moon itself tended to change the path from a horizontal direction and so prevent grazing impact. There are, however, some grooves or furrows on the moon's surface the most perfect example of which is the Great Valley of the Lunar Alps which looks very much as if made by a projectile at last arrested and in part deposited on the plain beyond. Near this also is the formation called the Straight Range which is remarkably suggestive of a glancing blow; as if a large body had failed to embed itself on the first impact and had tumbled along, ruffling the surface and shedding debris until its velocity was at last checked.

If it be correct to regard the moon as having been separated from the earth early in the history of our planetary system, there must have been a large amount of scattering at the time of separation. The earth would have retained the gases and water vapor almost wholly so that the moon would have gone off without an atmosphere. The moon and the earth also would gather up most of the material so scattered and the moon might then have accumulated its scars, or at least the earlier ones. The fall of any large mass would of course obliterate all smaller indentations made before its occurrence not only at the place of impact but for some

distance around it. This seems to have occurred with such craters as Tycho and Copernicus. If we go farther back in time and think of the possible building up of the sun and planets of our system by gradual accretions such as are now taking place when a meteor enters our air, but which at some time, as many millions of years ago, occurred on a far grander scale, we can understand the craters on the moon as the last records of such a process, and the Meteor Crater in Arizona as the largest known record on the earth, all others belonging to the earliest geological periods having been obliterated.

In the solar system the survival of the fittest rules. The numerous comets with highly elliptical orbits must succumb and be gathered up by those bodies like the sun, and by the planets which perform their rounds in a less erratic way with orbits nearly circular. If the conclusion be correct that the comets actually belong to and form part of our system, then the thought is permissible that at an early period they were innumerable and that they have been reduced and obliterated in feeding those masses, like themselves originally, which, however, possessed more conservative orbits, to use that term.

That the meteoric masses which come to earth are solid and have a structure strongly suggests that they are fragments of a much larger body.

The solidity suggests either a high temperature or a high pressure due to gravitational forces, or both. Particles floating in free space could never themselves form such dense and solid aggregations. When as in the Arizona crater irons we find diamonds, we are fairly sure of high pressure having existed. When we find also a coarse crystalline structure and segregation we think of a long time of slow cooling. When we see that the solid mass is not only coarse but that the parts are divided by fine crevices or small cracks we infer the sudden relief from high compression, when the material was cold and solid. In short, we infer that we have before us a fragment of a large body which in the long lapse of time had consolidated and cooled, and which later has been torn to pieces, disrupted into fragments large and small. Was it a collision of two large bodies in space, such as may have given rise to a great, irregular nebula like that in Orion? Doubtless collisions can occur but they must be very rare.

The order of nature, however, may easily involve the more or less close passage of large orbs, either still hot or cooled off, past each other at a distance of a few millions of miles. In such a case the stupendous tidal and centrifugal actions attendant on the neutralization of gravity on a line joining the centers of the two bodies must inevitably result in crushing them, as if an irresistible force were exerted in all other di-

rections than along the line joining them. This crushing would result in two streams or jets of material rushing out in diametrical directions at velocities of a great range of magnitudes, and they might in some cases, but not in all, be violent enough to produce very high temperatures and consequent vaporization. Each body so disrupted would then pursue its way no longer a spherical body but as a new-born spiral nebula, the internal forces of which would again set to work to gather up what matter remained outside of that widely dispersed in space. Thus new solar systems would be born from the wreck of those preceding. This involves a modification of the time-honored nebular hypothesis of La Place and is in line with the ideas of Chamberlin and Moulton in their planetesimal hypothesis.

We are led to suspect that this is indeed the process of nature, a process which has gone on from an infinite or indefinite past and which will continue as long as a ray of light can traverse the ether of space. To me the idea that the universe is like a clock running down is repugnant. Even though uranium, radium, thorium are disintegrating gradually, and we have no evidence of their generation by any process, there may be some source, as under the enormous pressures within a large orb, where such elements and perhaps others of still higher atomic weight and greater instability arise. Here again the law of survival holds, the electrons in the atom having unstable orbits being cast out in reducing the body to simpler and more stable forms, just as in the solar system the erratic comets must be eventually swallowed up and lost.